DOCUMENT RESUME

ED 055 809 SE 012 083

TITLE Undergraduate Education in the Plant and Soil Sciences, Proceedings of a Conference.
INSTITUTION Commission on Education in Agriculture and Natural Resources, Washington, D.C.; National Academy of Sciences - National Research Council, Washington, D.C.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE 69
NOTE 47p.
AVAILABLE FROM Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *College Science; *Conference Reports; Curriculum; Curriculum Development; Earth Science; *Plant Science; *Soil Science; Teacher Education; *Undergraduate Study

ABSTRACT

The proceedings of the 1967 Conference on Undergraduate Teaching in the Plant and Soil Sciences are presented in this publication. Seven individual presentations and reports from ten working groups review the adequacy and effectiveness of courses and curricula for undergraduate students; discuss instructional materials, methods, and equipment that might stimulate and improve the educational process; evaluate the role of the laboratory in teaching; and consider the means of encouraging continuing faculty development. (Author/PR)

HE

ED055809

COMMISSION ON EDUCATION IN AGRICULTURE AND NATURAL RESOURCES
AGRICULTURAL BOARD
DIVISION OF BIOLOGY AND AGRICULTURE
NATIONAL RESEARCH COUNCIL

Undergraduate Education in the Plant and Soil Sciences

PROCEEDINGS OF A CONFERENCE

National Academy of Sciences
WASHINGTON, D.C. 1969

Supported by funds made available by the National Science Foundation

Publication 1704

Available from

Printing and Publishing Office
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

Library of Congress Catalog Card Number 71-600161

ED055809

Preface

The Conference on Undergraduate Teaching in the Plant and Soil Sciences, held March 20 and 21, 1967, in Washington, D.C., was sponsored by the Commission on Education in Agriculture and Natural Resources (CEANAR), which is a unit of the National Research Council. The purposes of the Conference were (i) to review the adequacy and effectiveness of courses and curricula for undergraduate students in the plant and soil sciences; (ii) to discuss instructional materials, methods, and equipment that might stimulate and improve the educational process; (iii) to evaluate the role of the laboratory in teaching; and (v) to consider means of encouraging continuing faculty development.

Background data concerning the conference format and scope are presented in Appendixes C and D.

The Conference was restricted to about 25 invited participants and observers, representing four-year land-grant institutions, non-land-grant schools, and two-year colleges from widely separated geographic areas. Observers were selected from disciplines related to the plant and soil sciences.

The conference participants generally endorsed the curriculum recommendations of the Biological Sciences Action Committee on Plant and Soil Sciences,* which proposed an initial two-year core of courses (61 to 67 semester hours) including (i) 12 to 14 hours of biology; (ii) 14 to 15 hours of chemistry, 4 to 5 hours of which would be organic chemistry; (iii) mathematics through introductory calculus and probability; (iv) 8 to 10 hours of traditional and modern physics; and (v) 6 hours of earth sciences, 12 hours of social sciences and humanities, and 3 hours of agricultural science.

Although the conferees were nearly unanimous that supporting courses in the basic sciences should be the same as those taken by majors in those basic sciences, they agreed that those teaching basic courses should be encouraged to seek illustrative material from the fields of agriculture and the natural resources. A tutorial plan, earlier proposed by the Biological Sciences Action Committee on Plant and Soil Sciences, would augment the basic course, with a "tutorial" section conducted by an agricultural scientist from an applied department illustrating the application of principles to the fields of agriculture and natural resources. Lack of time precluded full consideration of this plan at the Conference; detailed information concerning this proposal is presented in the report of the Action Committee on Plant and Soil Sciences.

The Conference revealed a measurable reluctance to support combination of the common elements of professional courses and curricula in agronomy, horticulture, range management, and forestry, whereas a comparable fusion in the animal sciences has been successfully accomplished at a number of institutions.

*Formed jointly by CEANAR and the Commission on Undergraduate Education in the Biological Sciences (CUEBS). A copy of the Committee's report may be obtained from CEANAR, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418.

In my view, this reticence reflects three areas of concern. First, faculty members are aware that students in the plant and soil sciences do not feel that they are within their chosen field until they are familiar with the pertinent plant materials with which they must eventually deal. The relative ease with which the limited number of domestic animal species can be identified is in sharp contrast to the large amount of indigenous and domesticated plant material with which an agronomist, horticulturist, or forester is expected to be familiar. To accomplish the latter requires intensive training in systematics, preferably at an early stage.

Second, educators and professional people with strong ties to particular agricultural commodities are concerned lest identification with professional fields be lost if there is a shift in emphasis to a general plant science curriculum. A professional school that does not recognize and relate to the agricultural commodities of its state or region is likely to lose public support and, consequently, its effectiveness. Educational institutions might also do well to dispel such doubts as arise concerning the fate of professional departments. Release from such concern might well stimulate more interdepartmental discussion of course and curriculum contents and perhaps the development of programs that would permit students flexibility in selecting advanced courses.

Third, faculties of agriculture are increasingly conscious of the growing proportion of their students coming from urban backgrounds, where they have only limited opportunity for industrial or scientific agricultural experience. Unlike the medical profession, there is no internship system that would, for example, provide an agronomist with training in related sciences as well as practical experience in his chosen field. The conferees recognized the advantages of combining common elements of courses and curricula but felt that attempts must be made to resolve the dilemma expressed in the three points just noted.

One approach to more closely integrated curricula and courses would be to incorporate introductory courses in plant identification into the first-year curriculum of plant and soil science majors. The principles of nutrition, breeding, propagation, and management might then be combined into comprehensive plant and soil science courses that would challenge the student to relate to those species in which he has professed an interest.

The Commission expresses its appreciation to those who participated in the conference, particularly to those who presented special papers and to those who served as chairmen of plenary sessions or as chairmen or recorders of working groups.

R. E. LARSON, Chairman
Commission on Education in
Agriculture and Natural Resources

Contents

CEANAR Goals and Purposes of the Conference

R. E. LARSON

College of Agriculture, The Pennsylvania State University

Faculties in agriculture and renewable natural resources have consistently included teachers and scientists of great renown, whose contributions have been and are of incalculable value to the nation and to the world. Today we sense that lay people have a new appreciation for professional agriculturists and natural resource specialists.

There are concerns and fears today within the general public that have caused many to take a more careful look at those to whom food and fiber improvement and production, and natural resource utilization, are entrusted. With this new awareness, the professional agriculturist is also more intensely scrutinized.

The following factors have made important contributions to the shift from the relatively primitive agricultural and forest management of the early 1900's to the advanced enterprises of today:

- Exceptionally good natural resources of soils, water, forests, coal, oil, and generally favorable climates.
- A stable government.
- A virile, heterogeneous population not constrained by established methods but welcoming innovation and invention.
- Educational opportunities.
- Incentive based on monetary rewards.
- Adequate investment capital.
- Technologies such as: (a) oil-, gasoline-, or electric-driven motors and types of farm equipment that can use such power to advantage; (b) the processing or synthesis of chemicals essential to the nutrition of plants and animals or to the control of pests that interfere with production (fertilizers, insecticides, fungicides, antibiotics, herbicides, growth regulators, and urea supplement for ruminants); (c) the utilization of genetic information in breeding programs [hybrid corn, records (DHIA) and breed selections, artificial insemination, insect and disease resistance].

A list of this kind suggests that satisfactory progress has been and is being made, and for the United States this is true. However, changes are occurring in the world that place an increasingly greater burden upon us and upon students now training. Should the population of the underdeveloped regions of the world increase from the present 2.5 billion to 5.0 billion by the year 2000, food production in those areas would have to increase 200 to 300 percent to provide a basic 1800-calorie diet. Considering that these nations have increased food production by only 54 percent in the last 25 years, it is apparent that our level of progress must be achieved outside the United States.

How does all this relate to the purposes of this conference or to the goals of CEANAR?

The need for well-educated commercial farmers, and for technically trained assistants (specialists in pesticide operations, plant propagators, and herdsmen, for example), is increasing. Moreover, a greater number of professional agriculturists will be required by industries serving agriculture or utilizing agricultural products, by governmental regulatory agencies, and particularly by research and development agencies.

In "A National Program of Research for Agriculture,"* the needs of the U.S. Department of Agriculture, State Agricultural Experiment Stations, and industry for research and development personnel are estimated at 26,600 new agricultural scientists by 1977. This report is the result of an exhaustive study by state and federal personnel and was undertaken at the request of the Senate Subcommittee on Agricultural Appropriations.

A concerned interest in the types of research and development necessary to meet U.S. and world needs and in the responsibilities of the colleges of agriculture to prepare agricultural scientists adequately led in 1960 to the formation in the National Research Council of a Committee on Educational Policy in Agriculture.

As equally important problems in the use of resources, in pollution, in recreation, and in beautification reached the critical stages, and as heavy demands for trained personnel capable of working in these areas developed, the committee was enlarged and became the Commission on Education in Agriculture and Natural Resources.

A number of questions arose. For what professional goals are we training young people in agriculture and natural resources? Do existing curricula include sufficient background in the basic biological sciences, chemistry, mathematics, physics, or in the social sciences? Are our professional curricula and courses for BS students too closely concerned with vocational training? Are we overly concerned with species or should there be greater emphasis on principles? How do we resolve increased general education requirements with the need for professional courses?

The Commission is an NRC vehicle for examining these questions. Its purposes are twofold. First, and most important, it reviews trends in education for students majoring in agriculture and the natural resource fields; stimulates discussion, re-evaluation, and improvement in undergraduate courses and curricula; and prepares recommendations for the future development of academic programs. Second, it assists in the development of the agricultural and natural resource aspects of general education (for students in other fields).

The Commission has sponsored many activities. It has, for example, along with CUEBS, solicited the assistance of many highly qualified people in so-called action committees, each numbering six to eight scientists and educators, in the following fields: animal science, plant and soil science, food science, social science: bioengineering, natural resources, and agricultural education.

The Commission has made studies in the following areas:

*Report of a study sponsored jointly by the association of State Universities and Land Grant Colleges and the U.S. Department of Agriculture, October 1966.

- Delineation of purposes and goals of undergraduate courses and curricula in agriculture and natural resources.
- Adequacy of requirements in the biological sciences, physical sciences, and mathematics in agricultural and other natural resource curricula.
- Relation of courses and curricula in agriculture and natural resources to each other in the college or university complex.
- Improvement of course content and quality.
- Proliferation of highly specialized courses and curricula.
- Burdens facing economically disadvantaged institutions in presenting curricula in agricultural specialties.
- Increasing isolation of our urban society from the natural environment and resulting loss of emphasis on the relation between man's welfare and his control of the environment.

The Commission has organized this Conference on Undergraduate Teaching in the Plant and Soil Sciences so that a selected group of educators can consider academic and practical issues of the kind just mentioned. This is the second such conference, the first having been concerned with animal sciences courses and curricula. We are fortunate in having specialists such as Drs. Carew, Burger, Sherman, Snider, Campbell, and Deep, whose presentations will assist the Conference participants and working groups as they consider curriculum content, course content, instructional materials, methods and equipment, the laboratory, faculty development and as they assess the status of undergraduate teaching in the plant and soil sciences.

We ask you to evaluate the evidence that is provided and to add to this your personal experiences and observations.

If your deliberations result in recommendations that you feel would be advantageous to the students we train and the society they will serve, and if you can suggest effective means for implementing such recommendations, this Conference will be successful.

Future Directions for Plant and Soil Science Teaching

JOHN CAREW

Department of Horticulture, Michigan State University

A biologist of my acquaintance refuses to relate his instruction or his research to world social or economic problems. He offers two reasons. First, he considers such concerns outside the discipline of which he is so proud. Second, he equates academic excellence with detachment from practical matters. He is involved in what I would call liberal arts biology.

In contrast to this is biology that deals with management of plants and soils for economic purposes, which I would call agricultural biology.

We have, then, two kinds of biology. But should biological courses and curricula in agriculture be different than those taught outside agricultural colleges?

Before discussing this question, I should like to pay tribute to R. E. Larson, G. L. Stebbins, F. C. Steward, K. V. Thimann, G. A. Gries, and the late A. E. Darlow, and numerous members of committees whose reports I have read and who have covered this field thoroughly. I especially commend R. E. Geyer for his clear insight into the problems and for his articulateness.

What are the future directions for plant and soil science teaching? There is a need for consolidating and reorganizing curricula. Previous conferences have shown:

- A need for strengthening instruction in the fundamentals of biology that underlie agriculture.
- An awareness that the student population in agriculture has changed markedly in quantity and in precollege background and that teaching efficiency can be improved.
- An appreciation of the growing interrelationships of subjects previously taught in isolation.

Despite their well-known resistance to change, most professors and department chairmen will admit that instruction in plant and soil sciences could be improved. They will move willingly toward course and curriculum reorganization.

I should like to return to my opening remarks on the two kinds of biology, liberal arts and agricultural, and to my question, "Should biological courses and curricula in agriculture be different than those taught outside agricultural colleges?" My answer is a qualified "Yes," based on the premise that although the subject matter—cell biology, genetics, physiology, anatomy, biochemistry—may be the same, the manner in which it is taught varies considerably and can markedly influence the ability of graduates to contribute to the solution of present or future problems in agriculture and natural resources.

Course and curriculum reorganization must continually take into account the mission orientation of agriculture. We cannot accept a lower level of competence in agricultural biology than that achieved in liberal arts biology.

Therefore, as we move along the road to improved plant and soil science instruction, I should like to erect four road signs for your consideration, signs that I hope will influence not so much the direction of travel but the vehicle in which we move.

The first sign is labeled "Attitudes and Interest." In agriculture we are working with organisms in environments only partially controlled by man. Most plant scientists, especially those engaged in basic research, strive to develop model systems over which they have complete control and to concentrate on single cells, single processes, single organs, and single test plants. This is a logical approach that has led to significant new knowledge and has been useful in teaching. But it is an approach with restricted value because ultimately, in agriculture, we must deal with specific economic plants in their partially controlled environments.

The needs of agricultural plant and soil science will not be met if our students are exposed for long periods to a liberal arts biology point of view that tends to ignore research or instruction on economic plants; that stresses the need for purity of discipline and takes pride in an ignorance of practical matters; or that fails to motivate students with the land-grant philosophy of service to mankind.

One of the greatest educational problems in developing nations is the unwillingness of their biologically trained citizens to assume responsibility for the agricultural problems of their homeland. In this sense their instructors have failed; they have given them knowledge but not the motivation to use it wisely. In agricultural plant and soil science we must teach attitudes as well as biology.

The second word on this first road sign is interest. Many students enroll in agriculture because they enjoy working with plants. It is akin to the love that other students have for music or painting or engineering. It is a small flame that can be made brighter with care but that may be extinguished by a dull curriculum. Courses must be so planned that they will sustain and nuture the students' interest.

The second sign says "Diversity of Plants." In his talk, "The Place of Botany in a Unified Science of Biology," given at the 1966 meetings of the American Institute of Biological Sciences, Dr. G. L. Stebbins criticized the tendency of biologists to overemphasize the similarity of plants and animals and to give too little attention to their differences. A similar comment can be made with respect to many of our courses in botany, plant physiology, and genetics. Insufficient attention is paid to the diversity among plants which, in agriculture, is as important as their similarities.

Consider how important the differences are between plants in their response to selective herbicides, their requirements for mineral nutrients, their response to photoperiod, their flowering and fruiting habits, and their postharvest physiology.

Xanthium, Phaseolus, and Avena are valuable test plants, but unfortunately in research we cannot always extrapolate from test plants to economic plants. Courses in plant and soil sciences must also deal with the perplexing and often frustrating responses of apples, alfalfa, spruce trees, and tomatoes as well as their numerous cultivars. The diversity of plants must be an integral part of agricultural plant and soil science teaching.

The third sign is marked "Geographic Emphases." Should all our plant and soil science courses and curricula be alike, or is there a place for special emphases, perhaps related to the agricultural development of a particular state or region? Should a student in Florida experience the same curriculum as a student in Minnesota or Nevada? The student intending to go to graduate school should receive a complete education wherever he enrolls, but at the same time, he should be able to attend a school that, in relation to its location, can give special attention to particular species.

The fourth sign has but one word, "Skills." When we graduate students from departments of agronomy, horticulture, forestry, and plant science who have never been given the opportunity to grow a healthy plant, we have gone too far in our haste to eliminate practical courses. We must teach students the basic skills for growing representative economic plant species.

One hears no criticism of medical students practicing on cadavers or of liberal arts botanists practicing with microscopes or of biochemists practicing with scintillation counters. These practical laboratory exercises have recognized value. The plant and soil sciences should offer similar practice in the fundamentals of plant growing.

I have discussed four areas of concern related to the improvement of plant and soil science curricula and courses. As I see it, they relate more to how we

teach than to what we teach and to the attitudes of instructors rather than to course outlines.

I feel strongly about the future importance of agricultural plant and soil science. Despite our excellent record of achievement in research and education, I see unparalleled challenges ahead. Our involvement in world food production is just beginning. At the same time, the problems of plants and soils in the United States are far from fully solved. The situations we face are comple : and will require an extremely high level of competence among scientists, educators, and crop producers. We must strengthen our educational programs so that our young men and women are educated in the disciplines of plant and soil science and, of equal importance, are given the motivation and opportunity to apply their knowledge for the benefit of mankind.

Improving Instructional Materials for Undergraduate Teaching

A. W. BURGER

Department of Agronomy, University of Illinois

Each instructor has his own special approach to teaching. However, I believe that the present techniques and materials used in the plant and soil sciences can be improved. In discussing methods of improvement I will include ideas from the crop science teaching staffs of 38 departments of agronomy and from the Crop Science Society of America Teaching Improvement Committee, C-501, as well as my own.

The objectives and needs of undergraduate teaching in agronomy, the plant and soil sciences, can be met effectively only through a well-organized team effort. This team, involving researchers, teachers, and instructional resources personnel, must be efficiently organized and given adequate time away from their routine tasks to incorporate new research results into undergraduate teaching programs.

There are, of course, numerous ways of moving toward fulfilling the needs stated above. For example, the Crop Science Society Teaching Improvement Committee plans to concentrate on improving instructional materials for undergraduate teaching. The Committee recognizes that students coming into college are now much better trained than they were previously and that they deserve modern materials and equipment. Tentatively, the Committee's program calls for a team of experts to prepare six paperback books reflecting the subject-matter areas in each of the C-divisions of the Crop Science Society of America. The tentative titles of the books, which are to be in the series "Foundations of Modern Crop Science," are C-1, Current Concepts in the Breeding, Genetics, and Cytology of Field Crops; C-2, Fundamentals of Crop Physiology and Metabolism (to include material on weeds and their control through growth regulators); C-3, The Ecology, Production, and Management of Field Crops; C-4, Field Crop Seed Production, Principles and Practices; C-5, Turfgrass Manage-

ment; and C-6, Quality and Utilization of Field Crops.* It is entirely possible that the Committee will see fit to undertake other writing tasks. Also, since there is a continuing need for undergraduate reading material in crops science, revisions or renewals will be scheduled on a regular basis. Although some of the current publications of the American Society of Agronomy serve very worthy purposes, they are not readily usable in the classroom. Agronomy Monographs and Advances in Agronomy, for example, are excellent supplemental and reference materials for undergraduate teaching. Regular updating would make them even more effective—Agronomy Monograph Number 5, Corn and Corn Improvement, 1955, should be revised to incorporate more than a decade of new develments. We have hardly begun to provide material for crop science undergraduates.

Written material for undergraduate plant and soil science students must be supplemented by modern teaching aids and devices. Projection equipment should be permanently installed in the classroom and should be remotely controllable so that the teacher can stop it to illustrate a point. Readily accessible projection equipment is very much more likely to be used. A good teacher uses some form of visual aid in virtually every lecture or discussion. The minimum projection equipment in a modern classroom should include a 2 in. × 2 in. slide projector, a movie projector, both remotely controllable, and an overhead projector. The instructor should be informed of the many slides and films available in the plant and soil sciences and should know in which areas new films are needed.

Television and TV video tapes have been used in plant and soil science teaching and are now relatively inexpensive. They have the further advantage that, unlike ordinary movie film, they can be corrected relatively easily. Television offers many unexplored possibilities for improvement of agronomy teaching. For example, since magnifications of several thousand diameters show clearly on television monitors, it is possible to study plant tissue and even single cells as seen through microscopes.

There is little doubt that audiotutorial teaching methods should be fully explored. The advantage of this system is that it permits each student to move at his or her own learning pace and repeat exercises involving difficult concepts in order to have a better understanding of them. It frees the teacher for truly creative teaching as new developments in agronomic research become available. In a few years our libraries will undoubtedly house large numbers of short or single-concept films. It will be our task to see that among them are adequate films in the plant and soil sciences.

We would all do well to study the proceedings of a Conference on Single Concept Films in College Physics Teaching held December 1966 in Troy, New York, sponsored by the Commission on College Physics.† The goals of this conference were: (i) to gather in one report the presently available technological information on the production, distribution, and display of single-concept films in phys-

*The titles were subsequently revised to: (1) Crops and Man, (2) Propagation of Crops, (3) Crop Breeding, (4) Physiological Basis of Crop Growth and Development, (5) Ecological Basis for Crop Production, (6) Crop Protection, and (7) Crop Quality, Storage and Utilization.

†Report of the Conference on Single Concept Film in College Physics Teaching, published by Commission on Physics, College of Physics, Department of Physics and Astronomy, University of Maryland, College Park, Maryland.

ics; (ii) to encourage increased and broader use of these short films in college physics teaching; and (iii) to stimulate their production in college physics departments. We need only substitute the words "plant and soil sciences" for "physics." Thus far only fragmentary efforts have been made to produce, distribute, and use short films in the plant and soil sciences. Hundreds of these films, or video tapes, could well be made. "Soil Texture by Feel," "Water Retention as Related to Pore Size in Soils," "Particle Size Versus Sedimentation Rate," "Identification of Grasses by Epidermal Scrapes," "Epigeal versus Hypogeal Seedling Emergence," and "How a Corn Plant Grows" are examples of titles now available.

We need to provide much more scientific equipment to challenge our better-trained high school graduates. They must be exposed to some of the sophisticated equipment and techniques that research scientists use, as for example the use of radioisotopes in studying plant growth processes. Growth chambers or greenhouses are essential to good laboratory procedures. But scientific equipment is expensive, and adequate funds have been made available to only a few departments.

We need to organize instructional materials not only for land-grant institutions and other four-year schools but for junior colleges and two-year programs as well.

Everyone engaged in plant and soil science teaching knows that instructional materials need improvement. They simply are too busy with routine work and are not given the time needed to do the job adequately. We need a massive, highly organized program to launch the production, distribution, exchange, and use of instructional materials. The challenge is greater than ever before. We need space-age ideas to cope with space-age-and-beyond problems. The cost in time will be high, but it will be far more costly to fail.

In the Appendix we present two examples of the use of video tapes in instruction at the University of Illinois.

APPENDIX

Video Tape Introductions for the Crop Science Teaching Laboratory
(A. W. Burger and S. W. Saltzman, University of Illinois)

The introduction of the beginning crop science teaching laboratory can be accomplished through the use of video tapes. Video tapes have the advantages of: (i) standardizing the presentations in a precise, carefully planned and visually forceful way; (ii) allowing magnification of minute structures so that small plant parts, even single cells, may be viewed equally well by all; (iii) permitting quick editing and correction of errors; (iv) facilitating research into teaching so that different methods of presentation can be studied; and (v) providing for simultaneous showing in several different laboratories or on several different campuses. Student reaction is generally favorable to this medium.

Use of Single-Concept Video Tapes in Soil Science Instruction
(B. R. Sabey and S. W. Saltzman, University of Illinois)

Lecture demonstrations for an introductory soil science course have been performed and video taped under ideal conditions in a well-equipped and well-

lighted studio. The tapes can be transmitted without delay from a portable Ampex 660 video tape instrument located in the classroom or from a permanently installed transmitter in the studio. The latter method requires connecting cables and direct-line telephone between the laboratory and studio. Single-concept video tapes allow magnification of small objects, thereby giving every student a "front-seat" view. To insert a short video tape sequence into a lecture provides for welcome variety and better instruction without loss of time. Once a satisfactory demonstration has been taped, the risk of failures in "live" presentation is avoided. Of more than 200 students surveyed, over 95 percent favored continued and expanded use of this technique.

Instructional Technology in Higher Education

ROBERT C. SNIDER

Division of Educational Technology, National Education Association

The visual aids of the 1940's and 1950's are still very much with us. They have been vastly improved, and the array of media available today has been greatly expanded to include such things as the 8-mm short-film cartridge projector, the electronic learning laboratory, the electronic carrel, dial-access retrieval systems, computer-assisted instruction, a range of television modes, and programmed instruction.

However, the important change since the 1950's has not been simply an increase in the media and modes of presentation but rather a change in thinking about ways in which such methods can be most effectively made part of the teaching-learning process. They are no longer viewed as "aids," but rather as integral parts of a process involving men, machines, messages, programs, feedback loops, and behavioral objectives. There is a growing interest in instructional systems and ways in which operational research techniques can be applied to instructional problems through systems analysis.

At the theoretical level a working definition of educational technology might be as follows: The materials, equipment and other interrelated elements, including the necessary human components, of an assemblage that operates as an organized whole to encode instructional messages, to distribute information, and to make possible continuing design and operation of a sensitive instructional environment responsive to various feedback stimuli.

To paraphrase Ofiesh, Director of the Center for Educational Technology at Catholic University of America, educational technology is the development of empirically proven and validated learning processes, instrumented for replication purposes. This involves the systems approach to the instructional and learning problem. According to Ofiesh, the exploratory efforts made in the systems approach to education and training during the last decade support the thesis that educational technology and instructional systems design can produce predictable learner achievements.

Such a definition assumes a planned, cohesive, and systematic level of use

that is the exception rather than the rule on most campuses today. It also implies an important shift from a "hardware" orientation to a "process" orientation in planning for the use of the so-called new media.

The use of an instructional medium can vary greatly from one professor to another, and Finn (1966) has recently developed a useful model for considering a number of ways in which educational media can be used in college instruction. Professors of various subjects approach these new instructional processes in different ways, depending upon their degree of naivete and the nature of their disciplines. Thus, according to Finn, geographers as a whole are very knowledgeable about a wide range of media because of the nature of geographic investigation, information storage, and communication. Historians, on the other hand, are generally much less sophisticated about the use of media due to the nature of historical investigation, information storage, and communication.

Finn believes that educational media used in colleges and universities exists at several different levels, namely, the tool, data, behavior control, meaning, research, and systems levels.

At the <u>tool level</u> the instructor uses a medium of instruction for visual or auditory amplification as a part of the instructional process. Examples of this would be: the use of the overhead projector as a chalkboard during a lecture; the use of an individual, single-room, closed-circuit television system in lecture—demonstration situations; and the use of an amplifier to extend the range of voice in a large room.

At the <u>data level</u> other sources of data are used in addition to the usual printed ones, for example, motion pictures, photographs, video tape recordings, and audio recordings.

At the <u>behavior control level</u> media are used that involve programs into which much energy is expended in preparing the content, before it is used by the student, in anticipation of defined behavioral changes. Such program materials may be presented via a wide range of media. The instructor may or may not have been involved in the actual production of the material, but he does manage their use with students. Pretesting makes the results highly predictable.

Moving quickly over Finn's <u>meaning level</u>, which deals with building meaning into abstractions, and research level, dealing with the use of media support for research purposes, we come to the last and most sophisticated use of media—the <u>systems level</u>. At this level instructional materials are organized to achieve precise learning objectives, and a highly systematic design is required. Experimentation with such systems at the university level is increasing and has been stimulated by recent developments in computer-assisted instruction, large-scale television usage, and dial-access and other retrieval installations. These applications may be made to a single course, to an interrelated group of courses, to the curriculum of an entire institution, or to the cooperative endeavors of a number of institutions as in the instance of a statewide network.

Beyond these six levels of use we may also consider certain of the media as intramural and extramural transmission systems whereby television, audio lines, low-grade signal lines, and computer links can be used to provide mediated instruction.

Without going into the timeworn political, social, and economic reasons pointing clearly to the need for changes in our system of higher education, I would like to point out three recent developments that are already providing great impetus for a much wider use of educational technology in our colleges and universities.

The first is within the federal government, where considerable interest and support for technology in higher education has been generated. In the Higher Education Act of 1965, Title VI-A provides for a wide range of instructional equipment, and Title VI-B provides funds for faculty development to ensure effective use of new instructional media. Title XI of the National Defense Education Act has supported more than a dozen very successful educational media institutes for college professors and department heads directing NDEA institutes for high school teachers of history, English, and other established disciplines. Emphasis on faculty development receives much attention as new education legislation is formulated.

In 1967, the U.S. Office of Education issued a Request for Proposals for "an analysis and evaluation of present and future multi-media needs in higher education," which would provide the Office of Education, and college officials, with criteria necessary for the administration of laws providing funds for educational technology. Most of these Requests were sent to members of the new education business community, such as the General Learning Corporation and Philco-Ford.

We find government support to some degree behind nearly every innovative use of educational media on campuses today, and it seems certain that the trend will continue.

The second of these three developments can perhaps best be identified with the field of behavioral science. Within the past decade, great strides have been made in programmed instruction, instructional systems, computer-assisted instruction, responsive environments, and in many other applications of new learning theories. Behavioral scientists have had an important influence on the growing trend toward "learner-centered" individualized instruction. In discussing such work, Platt (1966) says:

> It has become clear that the psychology of positive reinforcement, of encouraged curiosity and reward, works much better than the psychology of negative reinforcement, as great teachers have always known. It is time to try out on a large scale the new discoveries and methods of this new educational psychology, discoveries such as the remarkable effect of early enrichment at ages 1 to 4, and methods such as . . . programmed learning and teaching machines and programmed texts that promise to make spelling and geography and physics and anatomy and many other subjects easier and more quickly mastered . . . The difficulty today is that these remarkable new methods have not yet been drawn together into a unified educational approach. We have a better engine, a better transmission, and a better steering mechanism, but they have not yet been fitted together to make a complete car. It seems very likely that, when they are all put together, these new developments in education will reinforce each other and will make possible further gains that would not come from any one alone.

The third development is what I have referred to as the new education business community. Since 1960 we have seen in this country more than 100 mergers both among large companies producing electronic equipment (hardware), and

among those producing books, programs, and other kinds of software. In most cases I believe it is naive to view such merged companies as cheap efforts to get some of the greatly increasing education market. Profit is an important factor, and it has been said that in our society the best way to develop a space capsule is to develop a market for it. It must be kept in mind, however, that many of these organizations come to the educational community with considerable technological resources which, in some cases at least, may be adapted and applied to instructional needs.

HIGHER EDUCATION MEDIA SURVEY

Four years ago the National Education Association and the Association for Higher Education published New Media in Higher Education, a book presenting about 90 case studies from some 40 institutions. We are now completing a study that will provide data for a similar volume with a much more current picture of quality and type of media being used, and on which campuses they are being used. This Higher Education Media Study has a total budget of about $20,000 and has collected data from 652 colleges and universities. Earlier the study project developed a Compendium of Evaluative Reports Contributed by Users of New Media in Higher Education (three volumes, unpublished) containing nearly 600 reports on media usage in well over 300 institutions of higher education. The project has also developed the Media Activity Inventory Directory (February 1967, 24 pp., unpublished), which identified 581 institutions using a combination of 21 categories of educational media. Sponsored in part by the Office of Education, our current study will provide the most accurate available inventory of media use in higher education. We hope that this study can be followed by an investigation of why certain educational media innovations have prevailed on some campuses and failed on others.

An important problem when such technologies are introduced into a teaching situation is what might be described as the man–machine problem. At the University of Houston a most elaborate study of faculty attitudes toward instructional television showed that resistance to television was reduced when a video tape recorder was introduced (Rossi and Biddle, 1966). Another interesting finding was that faculty members who favored television used more varied teaching techniques, were more interested in research, more experienced, more tolerant of students, and less puritanical or concerned about economic rewards of teaching than those strongly opposed to instructional television.

Many of us are convinced that higher education today is becoming more personal and more humanized through the application of educational technology. This approach permits an interaction of students and faculty that is not possible in our present system of higher education. It has been said, "There is nothing so unequal as the equal treatment of unequals." This, I believe, is an ill that can be cured through educational technology. I believe that many of the educational problems created by a technological society can be solved by the application of technology to the educational process.

REFERENCES

Finn, James D. 1966. A Possible Model for Considering the Use of Media in Higher Education. School of Education, University of Southern California. 7 pp.

Platt, John R. 1966. "Diversity," Science, Vol. 154, No. 3753, p. 1139.

Rossi, Peter H., and Bruce J. Biddle, editors. 1966. The New Media and Education. Aldine Publishing Co., Chicago. p. 283.

The Role of the Laboratory

J. A. CAMPBELL

Department of Chemistry, Harvey Mudd College

Although student and professor testimony suggests that much past and contemporary laboratory work is probably almost useless for the majority of students, laboratory work is the heart of scientific investigation and the basis of scientific advances. It thus seems wise to change the student laboratory rather than to delete it. The following criteria are suggested as leading to experimental approaches and to investigations of real, long-term value to all students and as giving an indispensable comprehension of what scientists do and on what they base their ideas. The sequence is in decreasing order of importance.

1. Direct appeal to real systems for information and ideas. The experimental sciences have an enormous advantage over nonexperimental fields in that the student can come into intimate contact with real systems and see how they behave. He can burn, pinch, and cut his fingers. He can smell and make other direct observations. He can observe unexpected events. He can see that no real system behaves quite according to the ideal laws and concepts. He may even discover something that his instructor had not anticipated.

2. Determination and control of variables. An important attribute of science is that it deals with systems that are reproducible if the variables are controlled. The search for such variables is an important part of the approach, and one in which the student in the laboratory can go beyond what can be presented in textbooks and lectures. He can also learn how much more difficult it is to control some variables than a verbal description of the system indicates, and he may in the course of his work discover a new variable or a new method of controlling an old one.

3. Quantitative measurement and determination of experimental uncertainties. Much of scientific activity ends up in qualitative observations, but it is hard to overemphasize the importance of quantitative measurements and of the experimental evaluation of the uncertainties in each of these measurements. Actual laboratory work not only makes the student aware of "errors" that occur in the work, but also that uncertainties are inevitable and that it is necessary to assess their effect and to minimize them. It is one thing to see data tabulated in terms of temperature, but a much more effective thing to try to determine temperature accurately and to estimate how precise is the measurement.

4. Active participation on planes other than intellectual. Much of our educational process is carried out in symbolic logic. Models are substituted for real systems, and more or less exotic symbols for the actual substances. Manipulations are carried out within an axiomatic framework, often with the result that the system is grossly overidealized. Many students who have difficulty with this approach find their true abilities and skills brought into play in the laboratory where dexterity, cleverness of experimental design, and observational skills are more important.

5. Background for lecture material and amplification of lecture experiments (demonstrations), filmed experiments, and text material. There seems to be a growing number of people who feel that lectures are most effective when they follow rather than precede laboratory. True, the purpose of the laboratory must be clear, and a definite question must be explored during laboratory time. It also seems that once a student has explored several real systems he is much better able to generalize on these results and to understand the more abstract, and more rapid, approach used in class. For example, lecture experiments can often be used to introduce a subject that is then followed up in the laboratory and then treated more thoroughly in subsequent classes.

6. Excitement of true discovery—observations and interpretations. It is not at all unusual for a student, in laboratory, to make an observation that is completely new to the teacher. It is even more likely that he will make an observation that is new and even startling to himself. It is commonly said that discovery requires a "prepared mind." How better can one prepare minds than to give them as many opportunities as possible to undertake discovery?

7. Cooperative venture in new field with major contribution from student. In many experimental fields it is surprisingly easy to base experiments on active fields of research. This is especially true in advanced courses where it is quite possible for a student to come up with real contributions to major research programs. A major problem arises in that the instructor does not "know the answer" to the experiment. This disadvantage may well be outweighed, however, by the excitement the student experiences and in any event may be minimized by having several students work on a single problem and compare their results.

8. Learning to phrase questions, not just repeat answers. Most professors would agree that the purpose of educating students is to get them to where they can strike out for themselves. It seems rather easier to have the student raise new questions in the laboratory than in the class, where he faces class pressure and the need to defend before a large group what he may think is a peripheral question. In the laboratory the questions and the methods of looking for possible solutions can be his own. If the questions are really new, the answers will also be new, reinforcing the worth of the laboratory.

9. Design and testing of experimental approaches. If a laboratory exercise is to be a true experiment it should involve something that is unknown, such as a new system, or a variation on an established technique. Students have the advantage of being "naive" with respect to established techniques and can quite often come up with surprisingly good suggestions toward improving them. Even if they do not improve a technique, they may well get considerable insight into how it was discovered in the first place, and why it is carried out as it is.

10. Repeating "classical experiments." There is much to be said for the neophyte in any field getting some direct contact with the beauty and simplicity of

certain of the classical experiments that have led to truly deep insights. It is probably folly to expect the student to place himself in the historical perspective of the original experiment, but there are many experiments for which the historical perspective can be set for him adequately and whose results are a true delight. Few students indeed enjoy redetermining over and over again values that are in the textbooks, but there are also few who do not enjoy occasionally determining some exotic values, such as the velocity of light or the nature of genetic variation, by simple bench-top experiments.

11. Learning techniques. Only a minority of students will spend their professional lives actually doing research. Those who do will pick up many techniques on their own. But whether they are or are not involved in direct laboratory work, a knowledge of techniques and of their limitations is something that can give them considerable insight into the design and interpretation of experiments and the difficulty of getting good results. One of the commonest complaints of repairmen in every field of modern technology is that the designers must never have to repair the equipment, for otherwise they would design it far differently. The same can probably be said for scientists who are not familiar with the basic techniques. Yet, note that I rank this as one of the least important of all the things that goes on in the laboratory. The laboratory experiment should not be designed to teach techniques, but should, rather, expect, even demand, good technique in order to achieve good results. If the experiment seems interesting to the student, and if the results continue to reward him, his drive to learn the technique will be more than adequate.

In summary, a good experiment should involve a student with a real system that he does not understand completely, in a situation where he can look for and control most of the variables and make intelligent guesses as to reasonable questions and possible answers. He should be able to make direct observations (preferably quantitative), interpret them in a rational fashion, have the excitement of surprise and discovery, and understand the system and the variables after he is through.

In-Service Faculty Education

IRA W. DEEP

Staff Biologist, Commission on Undergraduate Education in the Biological Sciences

The need for in-service education is widespread. One's education in any field cannot end in graduate school, because rapid developments will render it obsolescent within a few years. Dr. George A. Hawkins, Dean of the School of Engineering at Purdue University, expressed it well when he pointed out that during the first five years after graduation most engineers are inclined to wish their study programs had contained more practical courses so they could immediately begin to solve industry's day-to-day problems, but that during the next ten they wish they had taken more courses in mathematics, physics, chemistry, and engineering science—the young man who has not kept up is annoyed with his for-

mal education on discovering that he is short on new theoretical knowledge. Then, in the period 12 to 25 years after graduation engineers voice the need for more courses in management and administration, skill in public speaking, writing, and finance, a feeling that stems, of course, from the practice of rewarding outstanding professionals by placing them in administrative positions. And finally, after 25 years, graduate engineers reflect greater desire for a background in fine arts, music, literature, and drama. They now approach the leisure of retirement and feel uneasy about having neglected cultural pursuits. Dean Hawkins summarizes, "It is meaningless to talk of technical obsolescence ten years after graduation. If it does catch up with the engineer it doubtless began on commencement day."

Many professional people readily meet the needs of in-service education, others do not. Before considering the kinds of programs useful to those who must be updated, it might be worthwhile to consider the factors that lead to obsolescence, as a way of focusing on the preservice training needed to counteract it.

In some cases the environment, primarily the nature of a person's job, frustrates his attempts to keep up to date. The daily routine of the job may be so time-consuming that self-training is not feasible. The classical example of this is the teacher with 20 to 25 class contact hours a week, who advises students and is involved with campus committees. A research worker may find himself in a similar situation if there are too many routine manipulations to be made, and if technical assistance is not available. The resulting impasse is harmful to both employer and employee, because eventually the job will surely change, while the person concerned will have had no opportunity to change with it.

A second factor influencing obsolescence is the basic nature of the individual and his background. Even when the environment is favorable, it remains for the individual to take advantage of his opportunities, and some do not. Is this a strictly personal thing, or can something be done to motivate these individuals? What elements in graduate education today are designed specifically to help a person in the future? How does a major professor say, "You need this kind of background, or this kind of understanding, if you are to keep abreast of new developments?" Faculty members, in general, have not paid sufficient attention to these questions when they design graduate programs.

The Pre-Service Subpanel, Panel on College Instructional Personnel, of the Commission on Undergraduate Education in the Biological Sciences (CUEBS) has made an effort to identify elements in graduate education that would be useful in minimizing obsolescence. These elements are discussed in an article in the CUEBS NEWS, February 1967, titled "The Prevention of Obsolescence in Future Teachers of Undergraduate Biology."

Examples of the kinds of accomplishments recommended by the Subpanel are: (1) an understanding of the structure of biology; (2) an appreciation of the relevance of the history of science to what is known today and what will likely be discovered tomorrow; (3) an understanding of information storage and retrieval systems; (4) an understanding of pedagogy and effective use of teaching aids; (5) a background in mathematics as a foundation for quantitative biology; and (6) an understanding of instrumentation on a principle rather than on a "black-box" basis.

The Subpanel has made a significant beginning, but the all-important job of getting more of these elements included in graduate programs lies ahead.

What opportunities are available to persons who recognize the need for further training but who need more time than is available while they are on the job?

FELLOWSHIPS

Prestigious fellowships, such as the Guggenheim, Fulbright, National Science Foundation (NSF) Senior Postdoctoral, and to some extent the NSF regular Postdoctoral, are highly competitive, and the person who is truly in need of updating is at a distinct disadvantage in his efforts to obtain them. The NSF Science Faculty Fellowships, which are available to either predoctoral or postdoctoral candidates, are somewhat less competitive and are designed more for people who need an opportunity to update their knowledge.

NSF COLLEGE TEACHER PROGRAMS

The Research Participation and Summer Institute Programs of the NSF offer excellent opportunities for undergraduate teachers. The Research Participation Program allows a college teacher to move into an on-going research program during the summer and, possibly, to continue research on a limited basis at his home institution during the academic year. This may satisfy a need common to many teachers whose commitments in the classroom are too great to allow adequate participation in research. A Summer Institute allows a person to spend several weeks reviewing recent developments in one or more areas in biology. Since most personnel in schools of agriculture are on 12-month appointments, it would probably be necessary for a participant to obtain leave. Participation in such programs should make a person more effective in his job, and since the NSF stipends are rather low, it would seem appropriate that the home institution provide at least partial support.

To one who feels very much out of date and needs more study than can be obtained through Summer Institutes or Short Courses, the Academic Year Institute Program offers an attractive possibility. However, AYI programs for college teachers have received very meager support; in biology only two were funded for 1967—1968—one in radiation biology and one in nuclear science. Also, the stipend is inadequate to support a college teacher comfortably during a leave of absence.

The CUEBS Panel on College Instructional Personnel has a Subpanel on Institutes, Conference and Refresher Courses that considers how to get the greatest benefits from established programs of NSF, the U.S. Office of Education, and other such agencies. Are sufficient numbers of good proposals being written by biologists; are programs available in organismal genetics, ecology, and anatomy as well as in cytology, biochemistry, and molecular genetics; are proposals coming out of the South and West as well as the Northeast and Midwest?

NSF SPECIAL PROJECTS PROGRAM

The Special Projects Program of NSF supports innovative programs for inservice education of college teachers such as that now operating in Nebraska.

Each year a number of teachers in Nebraska colleges have the opportunity to spend a year at the University of Nebraska taking course work and doing research. In each case a replacement teacher is supplied to the college. This program also provides for research participation and makes seminar speakers from the University of Nebraska available to the colleges. The CUEBS In-Service Subpanel of the Panel on College Instructional Personnel independently outlined a regional program for Biology Faculty Redevelopment that has many elements in common with the Nebraska program. The Subpanel is attempting to interest biologists in preparing proposals for several such regional centers.

PROFESSIONAL SOCIETIES

Some of the professional societies, such as the Botanical Society of America and the American Phytopathological Society, have encouraged preparation of proposals to NSF for funds to support institutes or short courses for college teachers. In other instances, conferences have been held by professional societies on the occasion of national meetings to discuss recent developments in the field. Some societies, on the other hand, have been very inactive in the area of education. The American Institute of Biological Sciences has established an Office of Education, and I believe we can look to this Office for leadership in stimulating greater interest in problems of education among professional societies.

In summary, there is a great need for more in-service education for college teachers. The real challenge lies in developing more good programs and stimulating college teachers to take advantage of them. Funds to support such programs should be sought through state budgets, registration fees, businesses, professional societies, and private organizations. The needs cannot be met by support from federal agencies alone.

Plant and Soil Science Teaching in Two-Year Institutions

G. ALLEN SHERMAN

Mount San Antonio College

What is the status of the junior college in the United States today? And, of particular importance to agricultural educators, what is the status of agriculture in the junior colleges of the nation? At the present time, about 100 two-year institutions offer agricultural programs, and about 50 others offer some courses in agriculture. If the latter 50 schools increase their offerings, we will have about 150 established programs in agriculture.

The United States Office of Education estimates that 500 new junior colleges will be started in the United States in the next ten years. The decisions that these schools make on the kinds of programs they will offer—even the decision on whether they will include agriculture—will depend greatly on the leadership and guidance provided by all of us in agricultural education.

During the past two years, my staff and I have had the opportunity of visiting about 50 junior colleges and 15 four-year colleges in all parts of the nation. We

found very active interest in starting or expanding junior college systems. In New York, for instance, there is a plan to have a junior college within commuting distance of 95 percent of all students in the near future. In California, every high school district has been required by law to make arrangements to be in a junior college district since the fall of 1967.

In some states we found that four-year colleges tended to look at the new two-year schools with scorn and distrust—scorn because here was a young upstart of a school with one agriculture teacher trying to teach several subjects; distrust because enrollment at the new school was seen as a threat to enrollment at the four-year college.

As for one teacher teaching many subjects, some of the concern was warranted. Such conditions do exist. I think we must remember, however, that the same conditions may have existed when the four-year colleges were just beginning. Specialization in teaching can come only with increased enrollment. As for the competition for students, I believe one would have to examine the high school records to see how many of these students in junior college would have been eligible to attend the university as freshmen. In most cases they would not have been.

I believe that as you take a closer look at these new institutions, you will begin to see them more as an asset to the four-year college than as a liability. They will be seen as a source of new students rather than as competitors.

The majority of these new two-year institutions are in their infancy and are looking for guidance and direction on what agricultural programs to offer. We found that even some of the older two-year institutions that have had successful programs are looking for ways to change and improve. Those of you in the four-year colleges can be of service to the new institutions by helping with surveys or by identifying areas of need for training programs.

I believe there is a common misconception that should be cleared up today: that junior colleges usually grow until they become four-year colleges. Although this could happen and has happened in some places, most of the junior colleges have been established to fill a specific need in our educational system and will remain as two-year institutions.

Basically, the junior college has three functions. One of these is to offer a transfer program leading to the four-year college. Some students who may be qualified to go directly to the university may choose instead to go to a junior college closer to home. The second function is remedial. Many students who are not qualified to enter the university will attend a junior college and, provided they can maintain a C average, transfer to a four-year institution. The third function is to provide a vocational—technical education.

It is this third function that is probably the most important; the aim of most junior college students is to complete two years of study and then go to work. This is a function not performed by most four-year colleges.

The remedial function should interest most agricultural educators because it is here that good potential students, those who could not enter the university directly from high school, have an opportunity to prove themselves. University enrollments are growing so rapidly that many students who may be capable of graduating are turned down. Some of the four-year college people whom we visited felt that the present testing program for entrance does not favor students who have attended small rural high schools and are interested in agriculture. This group, plus those who are eligible for entrance but attend a junior college first, can make a sizeable contribution to upper-division enrollment where it is

needed most. In state colleges in California where agriculture is taught, students transferring from junior colleges outnumber entering freshmen two to one. This trend will undoubtedly occur in other states as junior colleges are started.

In 1962 there were 70,000 high school graduates who had taken vocational agriculture. About 50 percent of these students went directly into farming or other occupations. Between 18 and 53 percent of the others indicated that they planned to continue their education, the percentage varying from one state to another. The highest percentage was in California, where five four-year institutions and 32 junior colleges offer agricultural programs.

We found that many kinds of agricultural programs, ranging across the breadth of agriculture, are being offered in our two-year institutions. Because most programs are job oriented and tied to local communities, this wide variety is probably desirable. We found that a general upgrading is taking place, and that programs are becoming more technical. This has been due primarily, of course, to the changes that have been taking place in farming and related business.

We found much uniformity in curricula in the plant and soil sciences. Many of the curricula include courses in soils, pest control or entomology, farm mechanics or agricultural engineering, marketing, agronomy, forage crops, and farm management. A wide range of agronomic subjects is offered. In the curriculum guide that we are preparing for the United States Office of Education, we are suggesting additional courses in the plant and soil sciences—courses offered by only a few two-year institutions at present. These courses are crop botany, plant diseases, irrigation and water management, weeds and weed control, soil management, and seed production. They are intended for a two-year technical program and are not necessarily designed for transfer students.

Although the courses named are not planned as transfer courses, I believe that some of them would be acceptable for lower-division transfer credit. Acceptability would depend on the quality of instruction in the two-year school and on the nature of laboratory and other equipment. In the two-year schools, the main function of instructors is teaching, not research; and we found many examples of outstanding teaching. Our curriculum guide will include recommendations on laboratory equipment.

Now that we have reviewed briefly the status of agriculture in the junior college, what is the role of the four-year colleges and universities—if any? You do have a role—an important one; it is the role of leadership.

The first step, I believe, is for university people to acquaint themselves with junior college programs. Many of these people criticize the programs though they have never been on a junior college campus. Most of the teachers of two-year programs in agriculture will be graduates of four-year institutions. If they cannot perform their duties properly, it is because the four-year institutions have not trained them properly. Visit the various schools and see what is going on.

In addition, I would recommend that some sort of liaison committee be established. Such a committee has been in operation in California for several years. Membership is made up of personnel of the Bureau of Agricultural Education who represent the high schools, the university, the state college, and the junior college teachers and administrators. The committee meets twice a

year, at a different school each time, to discuss mutual problems. This committee has been very valuable in promoting articulation between the various levels of agricultural education.

All the four-year colleges in California have articulation agreements with the various junior colleges. These are formulated by sitting down at meetings and going over each course to decide whether it will be acceptable for transfer. After agreements have been made, both schools are bound by them until they are renegotiated. This makes it much easier to counsel students who may wish to take a transfer program.

The universities can provide leadership by seeing to it that some of the new junior colleges do have agricultural programs. Not all new junior colleges will or should have them, but those in important farming areas should offer some type of program. Help from the four-year institutions in promoting, planning, and staffing these programs will do much to ensure success for them and will eventually provide mutual benefit.

The demand for teachers in these new programs will be great during the next ten years. Here the four-year institutions can assume perhaps their most important role, because it will be up to them to train the teachers. Previously, such teachers have come from the ranks of high school vo-ag teachers. Now there is a feeling, among some at least, that this may not be the most desirable source. It will be up to the faculties in the four-year institutions to find what kind of teachers are needed and how best to train them.

In reading the proceedings of some of the meetings of educators in the four-year institutions, I have noticed a trend toward the combination of lower-division courses. The reason seems to be to attract students from other majors. I hope that you will examine that trend very carefully. There is no doubt that lower-division courses can be changed to accommodate students from several agricultural majors and aid enrollment. This could be a needed change. Personally, I doubt that we will attract students from other majors by reducing the number of agricultural courses in the lower division and increasing the number of basic science courses. In fact, I believe the opposite to be true. Agricultural students like to get some courses in their major each year rather than waiting until their junior year. I believe that we need a balance between the basic sciences and the production courses in the first two years of study.

A core of lower-division courses in the plant and soil sciences can be developed that may be offered in the two- or four-year institution. I believe that this can be accomplished without disrupting the terminal function of the junior college and without penalizing the student who transfers to the university.

In summary, I would like to stress that the number of junior colleges will increase. If many of them develop good agricultural programs, they will be an asset to the total system of agricultural education. Liaison between two-year and four-year institutions is desirable as a way to establish articulation agreements.

Demand for teachers will increase considerably, and these teachers must be trained by the four-year institutions. This need will be for both preservice and in-service training. These teachers must be able to teach more than one subject.

Finally, I recommend developing a core of lower-division courses in the plant and soil sciences that could be offered by either type of institution.

Curriculum Content*

Although it was recognized that there are many two-year undergraduate curricula, this report considers only four-year programs.

Primary attention was given to the increasing importance of ecology, as reflected in the following statement prepared by Dr. Galston, which was endorsed by the Committee:

> We live in an age in which the interaction of plants, man, and environment has become overwhelmingly important. In fact, man's ability to prosper, even his survival, may depend on a better understanding of this interaction. We recommend the development of courses, to be offered to all students in agriculture, that will deal with these problems.
>
> We also consider it desirable that new curricula be developed to train specialists in this area. Such curricula should include biology, atmospheric chemistry and physics and such topics as city planning, architecture, and certain aspects of social science.

The merits of an orientation course in agriculture, as suggested by the Action Committee on Plant and Soil Sciences, were discussed and the general concept endorsed, with the reservation that it be designed differently from most "orientation" courses. It should reflect the history and development of agriculture and its economic, social, and cultural significance as the basis for man's survival on an increasingly crowded planet.

It was generally agreed that the role of agriculture in international affairs will become increasingly important as man faces the realities of the world's food budget, but it was not clear precisely how this might affect curricula in agriculture. The following statement, prepared by Dr. Peirce, was endorsed by the Committee:

> Students should be exposed to agricultural programs and problems beyond the borders of the United States. While excellent source material is available for in-depth discussions of world crops and of trends in world food production, it is evident that most resident faculty are not familiar with social or religious customs or economic systems of problem areas of the world. It is therefore recommended that staff, and possibly student, exchanges be encouraged as a mechanism for improving understanding and teaching effectiveness.

The curriculum recommendations of the Action Committee on Plant and Soil Sciences with regard to chemistry, physics, and biology (Table 1) were discussed and were considered to be generally acceptable. The level of mathematics that should be required was given special attention, but no agreement was reached. Dr. Bigger's statement on this issue was adopted:

> Realizing that changes in mathematics are likely to occur in the future, the committee believes that proficiency in mathematics, including introductory calculus, should be a standard requirement.

*Richard J. Campana, chairman of the working group; G. Allen Sherman, recorder.

TABLE 1. Two-Year Core Curriculum

Course	Semester Hours
Agricultural Science	3
General Biology	8–10
Cell Biology	4
General Chemistry	10
Organic Chemistry	4–5
Introductory Calculus	3–4
Probability	3
General Physics	8–10
Earth Science	6
English and Communications	6
Humanities	6
Total:	61–67

While at present there is no obviously feasible way to start a "marine biology" curriculum in agriculture, it was deemed wise to recognize that agriculture has a responsibility in harvesting the sea and to look forward to a training program, interdisciplinary with other biological sciences, that could affect the undergraduate curriculum and provide an additional basis for broadening its base.

There was no consensus on the question of combining curricula, but it was recognized that combining curricula could be most advantageous if the net result was better for students and would stimulate each of the groups involved. It was recognized, also, that combination of curricula, *per se*, is not necessarily desirable and should be evaluated carefully in each instance.

On the question of separate courses in supporting disciplines for agriculture students, it was generally agreed that they should take the same courses as all other students, but that an effort should be made by instructors to use agricultural problems as examples where possible.

Course Content*

A major problem in many colleges is that the students come with highly heterogenous backgrounds. Those who start their plant science work as freshmen have graduated from an array of different high schools. Others, especially transfer students, do not start agricultural plant science training until their junior year. And, in any event, the educational objectives of students in the plant sciences vary greatly—some are graduate-study oriented, others lean toward management or agri-business.

Group members generally agreed that a course in agricultural plant science could be developed that would fit the needs of this wide range of student preparation but were divided on the advisability of requiring a basic course in biology

*N. C. Merwine, chairman of the working group; Ralph R. Smalley, recorder.

as a prerequisite. They felt that the course should be based on principles rather than practices, the latter to be included as illustrative material. In order to build as broad a base as possible and to develop the total national and international aspects of plant science, examples should be drawn from agriculture worldwide. The group could not reach a consensus on the proper role of a laboratory in such a course and suggested two alternatives: (i) a laboratory in which the students gained experience in working with plants themselves or by contact with research work, and (ii) a program substituting television programs, slides, single-concept films, and film strips for formal laboratory experience. It was agreed that the course should be prerequisite for advanced students in special areas, although these special courses might require additional prerequisites from other science disciplines, such as organic chemistry and biochemistry.

In many institutions there is a tendency to overlook those aspects of plant physiology that bear on soil and water relationships and to approach the subject from a purely biochemical viewpoint. An introductory treatment of soil and water relationships should be a part of the initial plant science course, leaving more detailed training for advanced courses.

Advanced courses in special areas should at some point include protein synthesis and plant biochemistry as affected by environment and by management. The professional societies should be encouraged to develop courses and teaching approaches that would meet this need.

Training in soils should include physical properties as related to load capacity and drainage, urban development, highway construction, and industrial and recreational use.

There is a need for a well-defined course sequence in plant science from which students would be excepted by examination only.

There is a generally recognized need for broadening the appreciation of the national and international scope of agriculture and natural resources.

Instructional Materials*

The materials available to teachers of undergraduate plant and soil science are seriously inadequate. This is a continuing program, and frequent revision of instructional materials is essential if information is to remain current.

- In the area of text improvement the group took note of the Crop Science Society Teaching Improvement Committee's plan to prepare a paperback series, "Foundations in Modern Crop Science," at the junior-in-college level, and applauded their expressed intention of revising these texts at frequent intervals. Similar efforts are needed in other major areas, not only for advanced classes but for beginning classes as well.
- A rapidly emerging technique, thus far most effectively exploited by physicists, is the "single-concept film." This approach has immediate application in teaching plant and soil science, for it permits the individual student to

*W. A. Williams, chairman of the working group; D. P. McGill, recorder.

move at his own pace and to receive individualized demonstrations. Some colleges have already moved in this direction, and it would be well to encourage frequent film exchanges. The group urged that an article be prepared for the Agronomy Journal and BioScience describing the technique, and that lists of available films be published by professional societies in their journals, to be updated as new films become available.

- The professional societies in the plant and soil sciences should be reminded of the desirability of reprinting reports of recent significant discoveries, recast in "Scientific American style" as an aid to student understanding.

Instructional Methods, Equipment, and Facilities; and the Laboratory*

Instructional methods, equipment, facilities, and teaching laboratories should stimulate thought processes, particularly as they involve problem solving. Students should have the opportunity for independent study and experimentation. For maximum interest and achievement, it is important that they be actively involved, mentally and physically, in the learning process.

The group felt that the various disciplines can best reach their common objectives by sharing ideas through conferences and workshops that provide the stimulus necessary to compile and make available resource information in the various disciplines. The Commission on Education in Agriculture and Natural Resources can serve as a catalyst to this end.

INSTRUCTIONAL METHODS

Certain instructional methods, such as the audiotutorial system and programmed manuals, offer excellent approaches. Both have a place in undergraduate education.

Suitable source material is needed. Paperback manuals and reprints of selected research articles offer some help. Reprints of selected research articles could be followed by critiques and a series of questions designed to assist students in interpretation.

Action

- Appropriate societies should take the lead in preparing and publishing programmed text materials and paperback source books.
- Someone must initiate conferences and workshops between departments, using audiotutorial systems as a way of sharing experiences with the method. The proceedings of these conferences would provide guidance for other users and potential users.
- Interested departments need help in securing financial assistance for implementing their programs.

*F. C. Himes, chairman of the working group; Rodney J. Fink, recorder.

INSTRUCTIONAL EQUIPMENT

The group felt that there should be a desk-top TV facility in each lecture room. Film clips should be available for both movie and TV, especially for teaching laboratory techniques and procedures, single concepts, and principles, as well as to show time-lapse sequences. The various types of projection equipment should be readily available as needed.

Research and analytical apparatus should be included in equipment available for instructional use, but only to assist the over-all learning process, not as an end in itself.

Action

Various society groups should be encouraged to prepare exercises that include quantitative determinations. Instrument manufacturers should be encouraged to provide single-purpose film clips describing their various instruments. Sources of funds for securing these instruments must be sought.

INSTRUCTIONAL FACILITIES

Classroom and laboratories should be flexibly designed. Currently available guidance, and perhaps new material, should be made available to institutions planning new classroom and laboratory facilities.

Action

Currently available information concerning these needs should be evaluated, supplemented as necessary, and distributed to potential users.

THE LABORATORY

In his laboratory experience, a student must be involved in creative thinking and exploration. The student should gain experience in problem solving and attain essential skills and techniques; he should enjoy an interchange with other students as well as with the instructor. Laboratory exercises that follow a "cookbook" approach should be held to a minimum. Work—study programs for majors should be encouraged whenever possible. The student must learn to observe and interpret plant growth and plant and soil interactions. For most effective results, the laboratory and lecture should be coordinated and integrated. When possible, the laboratory should offer opportunities for advanced learning. The laboratory process should utilize and apply information and knowledge that a student has gained in previous courses. Each instructor should continually evaluate the laboratory to determine its contribution to the over-all educational objectives of the course.

Action

Greater interchange of ideas and of effective laboratory approaches among instructors is desirable. Perhaps the chief avenue for this interchange is at meetings of the respective plant or soil professional organizations. Interchanges with other disciplines should, where possible, be a feature of these meetings. Source material should be compiled to provide greater variety and over-all improvement of plant science and soil science laboratories.

Faculty Development*

This group identified problem areas and proposed possible solutions in preservice training and in-service improvement of teachers.

PRESERVICE TRAINING

The Committee was concerned that bright young students are not receiving appropriate inducement to enter the teaching field—and that their attention, especially at the graduate level, is too strongly directed toward research.

Problem Areas

- How can capable young peopled be motivated to engage in undergraduate teaching?
- How can preparation for teaching be improved?

Proposed Solutions

- Provide opportunity for students to get teaching experience at both undergraduate and graduate levels.
- Make teaching a highly respected activity of the scholar through (1) tangible reward, such as accelerated advancement, for good teaching; (2) publicly recognizing good teachers.
- Develop seminars or courses on teaching methods and techniques.
- Provide guided teaching experience.

IN-SERVICE TRAINING AND PERFORMANCE

As far as in-service training and improvement are concerned, much attention was devoted to problems of evaluating teaching. In this the opinions of the teachers and their students would be most beneficial.

*M. A. Massengale, chairman of the working group, D. G. Smeltzer, recorder.

With regard to assuring the continuing improvement of teachers, it was agreed that soil and plant science teachers, especially those who have research responsibilities, are reasonably familiar with the significant literature and recent research developments. The principal issue seemed to be that not enough time is devoted to updating course content and to presenting the material effectively. Many activities compete for the students' interest. The teacher needs professional help in making more efficient use of his time in developing teaching techniques and learning how to utilize new equipment and materials as they become available.

Problem Areas

How can teaching be evaluated?

- How can good teaching be rewarded?
- How can teaching be improved? How can on-campus opportunities for improvement of teaching be developed? How can off-campus opportunities for improvement of teaching be developed?

Proposed Solutions

- Ask faculty members to make studies and propose criteria and systems for evaluating teaching.
- Ask students and alumni for evaluation of courses, teachers, and curricula.
- Give uniform examinations to students after completion of appropriate courses.
- Award good teaching by financial compensation or public recognition.
- Persuade administrators to allocate more faculty time to teaching and for counseling students. Administrators can help in developing respect for good teaching and in fostering an awareness of the importance of good teaching in attracting good students.
- Teachers in plant and soil sciences should participate in discussions on course content in related courses. They should attend courses where one is prerequisite to another or where duplications or omissions may be involved in educational objectives. Communication within and among colleges on a campus should be improved.
- Encourage attendance at professional society meetings.
- Organize regional conferences or workshops on course content, teaching methods, and teaching aids.
- Encourage greater use of sabbatical privileges for improvement of teaching techniques.
- Encourage consulting, foreign service, and visits to industry.

Support for these last few activities should be predicated on a continuing program of teaching improvement rather than as an award for teaching excellence.

Teaching Introductory Courses*

The group felt that some type of general introductory course in agriculture should be given.

- When should introductory courses be taken? Freshmen should take an introductory course that relates agriculture to man and his environment. The "team"teaching idea (all members of the team to attend all lectures) was advocated as a successful approach.
- Should there be prerequisites? Basic science courses should be given as prerequisites for more specialized courses that are to be taken in junior and senior years.
- Should combinations of courses in several areas of plant and soil science be encouraged? Where feasible, to combine courses might reduce the number of course offerings and avoid unnecessary repetition.

Frequent evaluations of introductory courses should be encouraged because of the growing number of transfer students who come from other college systems throughout the world. Changes and modifications best come from the faculty, but administrators and groups such as those attending this conference have a responsibility to communicate their ideas to their colleagues.

Teaching Plant Breeding and Plant Genetics, and Plant Pathology†

These disciplines are primarily professional, requiring undergraduate curriculum as background.

REQUIRED COURSES

All plant and soil science students should be familiar with plant function and variation. In this context, the Group recommended that genetics and plant physiology be required of all students. Plant pathology, closely related as it is to physiology and having implications for environmental problems, was recognized as necessary for some disciplines but should not be required of everyone.

INTRODUCTORY COURSES

The sourcebook now available in plant pathology will contribute toward improvement in this field, and the development of a series of paperback books treating specific topics and basic concepts is suggested. Audiovisual aids, such as 2 in. × 2 in. slides illustrating research discoveries and tapes of outstanding scientists and their research (illustrating concepts), must be used and made available through better organized distribution schemes. Professional society programs and refresher short courses are suggested as a means of implementation.

*E. C. Stevenson, chairman of the working group; B. O. Blair, recorder.

†Ervin H. Barnes, chairman of the working group; L. C. Peirce, recorder.

The major problem in teaching genetics is that students have very heterogeneous backgrounds, which restricts flexibility of laboratory programs. The group recognized the importance of exposing students to a progressive genetics laboratory situation in the introductory course and suggested that the course be open-ended and that films and tapes be used to show how living organisms may be used in the laboratory.

The group suggested that each of the disciplines discussed—genetics, physiology, pathology—is, in many respects, complementary to the others For example, the physiologist should recognize that disease may properly be interpreted as abnormal physiology. Considerations of this kind can improve student awareness of the organism in its environment.

SUBPROFESSIONAL TRAINING

It was agreed that the core program recommended for plant science students should be used for technician training also. The more advanced courses, customarily used to prepare students for graduate study, would probably be replaced in a technical program by management or techniques courses. For a number of technician jobs, training at less than the BS degree level was recognized as adequate.

IMPLEMENTATION

The need for continual refresher training courses in pathology, physiology, and genetics is critical, in view of accelerating research in these disciplines.

Teaching Plant Physiology*

COURSE CONTENT

The group was in general agreement with the recommendations for an introductory course in plant physiology as suggested by the Action Committee on Plant and Soil Sciences. Specifically, however, the group recommends that plant physiology be taught on the basis of life functions.

Plant Nutrition Water, minerals, organic (including photosynthesis—biochemical, biophysical, whole-plant treatment; include influence of factors such as light, CO_2, competition, growth regulators).

Growth and Development Seed germination and dominancy; meristem, structure and control of activity; cell division and elogation; influence of hormones.

Influence of Photoperiod and Temperature

Flowering and Reproduction

*J. H. M. Henderson, chairman of the working group; Ralph S. Obendorf, recorder.

Stress Physiology Drought; temperature (heat tolerance and frost resistance); salinity.

Ecological Physiology Species interaction and competition; influence of applied chemicals, including pollutants and pesticides; plant sequence relationships.

INSTRUCTIONAL MATERIALS

- A series of texts applicable to any current course is available.
- Single-concept films and other aids where adequate equipment or facilities are lacking.
- There is no single manual adequate to cover the requirements for laboratory courses.

The Committee recommended that a sourcebook of simple laboratory experiments in plant physiology be developed and that the Commission on Education in Agriculture and Natural Resources urge such societies as the American Society of Plant Physiologists, the Botanical Society of America, the Commission on Undergraduate Education in the Biological Sciences, and the American Institute of Biological Sciences do so.

INSTRUCTIONAL METHODS, EQUIPMENT, AND FACILITIES, AND THE LABORATORY

- A laboratory is absolutely essential.
- Controlled environment facilities and a greenhouse, if at all possible, are highly recommended.
- Where facilities and experiments are inadequate, other methods such as single-concept films and film loops should be used.

FACULTY QUALIFICATION AND PREPARATION

Whereas the general qualifications of the faculty are the responsibility of the administration, it was felt that an instructor teaching the introductory course in plant physiology should recognize and meet the needs of the students in a plant and soil science curriculum.

Teaching Plant Ecology and Management*

Crop-oriented ecological veiwpoints differ from natural-resource-oriented ones. Both are important in planning present-day agricultural programs. Professional areas related to various commodities provide an almost unlimited array of approaches to problems and to working out solutions.

*Melvin S. Morris, chairman of the working group; E. C. Roberts, recorder.

The working group considered innovations in pure and applied ecology and in production-management concepts that influence course content, sequence of courses, combinations or substitutions of courses, and the general education of the college student.

PLANT ECOLOGY—PURE AND APPLIED

- Consider both pure and applied ecology and their relationships to production and management.
- Chief concern should be with course content, not with course title. Principles and concepts, rather than specific details or technology, should be emphasized. Stress new concepts, including systems analysis.
- Combinations and substitutions of courses are desirable and necessary to bring about reduction in the current emphasis on technology as such.
- Courses in ecology and management are increasingly difficult to schedule because of the current enthusiasm for core curricula. Where course work in ecology cannot be scheduled until the junior year, management courses are often delayed until the senior year. It may be that professional and specialty courses will therefore have to be delayed until graduate school. Increased emphasis on economic, social, and managerial studies, on mathematics, computer science, and related basic science is crowding an already tight schedule. To continue adequate coverage of applied ecology and production-management courses, five-year professional programs or work at the graduate level may be necessary.
- As man manipulates the environment, including use of fertilizers, soil conditioners, and pest control chemicals, he must be alert to the effect of these materials on environment. Answers to current questions concerning pollution of water, air, and soil must be related to management through an understanding of ecological principles.

PROFESSIONALISM AND SPECIALIZATION

- Professional societies, in some instance, place rigid restrictions on curriculum content. Certification of the graduate depends on his having a fixed number of credits in prescribed areas. Civil Service openings require specific training of job candidates. These factors do not limit the development of course content in ecology and management but may make it difficult to schedule sufficient course work in this area.
- Faculty and students feel that specialization in various commodity areas is desirable. This specialization results in there being a wide variety of management- or production-oriented courses that have a distinct place in some educational programs.

PROBLEMS—DIVERSITY OF APPROACH

It is unreasonable to assume that problems related to course content, scheduling, and teaching in ecology and management can be solved the same way in all

institutions. A diverse approach is recommended that will reflect the specific needs of the area in which the institution has greatest influence. However, common goals that will increase efficiency and promote economy should be sought.

INTEGRATION OF CONCEPTS THROUGH ECOLOGY

The student in plant science is exposed to a wide variety of concepts that may be brought together and made meaningful through the study of ecological concepts and plant production and management. This integration is basic to sound education because, as the trend toward specialization continues, a method of relating one course to another is essential.

INTERFACE BETWEEN BIOLOGY AND OTHER ACADEMIC AND PROFESSIONAL DISCIPLINES

Communication between groups working on related projects is often difficult. The engineer and the biologist frequently reach a point where the solution of a problem depends upon a mutual understanding of the interface between their two disciplines. Because plant ecology and crop management have important contact areas with engineering, economics, meteorology, physics, and chemistry, communication with these groups should be improved.

Teaching Soil Science*

COURSE CONTENT

The group agreed that the basic subject matter that should be covered in an introductory course in soil science follows generally along the lines of most introductory texts in soil science.

However, the increasing need for service courses in soils for students of very diverse backgrounds and having different vocational aims raises new problems in course content, in prerequisites, and in developing illustrative material. To solve these problems may require establishing separate service courses and allowing some students who are not soils majors to enter higher-level courses without having taken the beginning soils course.

The courses and course sequence in soils appropriate for different schools will depend to a large extent on the needs of students within the area, particularly the needs for applying soils information to rural or urban problems.

INSTRUCTIONAL MATERIALS

The detailed subject matter in available introductory texts leaves much to be desired, primarily because it includes out-of-date material. Even so, intro-

*James V. Drew, chairman of the working group; Richard B. Corey, recorder.

ductory texts are superior to advanced texts; very few modern texts are available in advanced areas of soil science.

Several approaches could provide needed text material in soil science.

- Publication of anthologies of carefully selected and organized reprints of research papers dealing with selected areas of soil science.
- Rewriting and publication of research papers in the style and format of Scientific American articles. The original author might do the rewriting alone or in cooperation with a teacher.
- Experiments for the teaching laboratory could be prepared by research scientists, based on their own work. The Education Section of the Agronomy Journal could provide a good outlet for this material.
- A writing conference could prepare text material for introductory as well as advanced courses in soils.

INSTRUCTIONAL METHODS

The audiotutorial approach appears of considerable promise in providing flexible and effective methods of instruction, especially at the introductory level. One of the keys to its effective use will be the development of adequate visual aids, especially the single-concept film.

Two-way television could add new dimensions to teaching, especially at the graduate level. Two-way television would allow students throughout a given geographic area to obtain instruction from a top research man regardless of where he might be located. The two-way feature would also allow question and answer sessions to be carried on in conjunction with the lecture. Development on a university-wide basis would maximize use of the facility.

Grant applications for improved instructional material and methods should be encouraged.

FACULTY QUALIFICATIONS AND PREPARATION

The group generally agreed that prospective teachers need advanced degrees and research experience. That graduate students should be exposed to professors who use good teaching methods was emphasized.

APPENDIXES

APPENDIX A

Resource Paper for the Conference

PURPOSES OF THE CONFERENCE

- To assess the status of undergraduate teaching in the plant and soil sciences.
- To recommend action, if any, that should be taken to improve undergraduate teaching in the plant and soil sciences.
- To suggest mechanisms for implementation of recommended action.

SCOPE

- "Plant and soil sciences" are here defined to include the disciplines concerned with the management of plants and soil for economic purposes, including agronomy (crop sciences and soil science), horticulture, plant pathology, forestry, and range management.
- The conference will focus on the content of undergraduate curricula and courses in the plant and soil sciences, instructional materials and methods, equipment and facilities, the laboratory in undergraduate instruction, and faculty development.
- Attention will be given to introductory courses, courses in plant breeding and genetics, plant pathology, plant physiology, plant ecology and management, and soils.

BACKGROUND

Undergraduate teaching in the plant and soil sciences seems to have progressed markedly in recent years, especially through increasing emphasis on scientific principles rather than current practices. Nevertheless, additional changes may be indicated by such current trends as:

- Research advances in the biological sciences, especially developments in molecular and cellular biology and in the physical sciences.
- Ferment and change in science teaching at both secondary and college levels.
- Accelerating changes in the scientific, economic, institutional, and other characteristics of agriculture,* especially new developments in research and practice in the plant and soil sciences.
- Changes in courses and curricula in agriculture, including a reduction in the number of hours devoted to agricultural courses in the undergraduate curricula, and the consolidation of courses and curricula in the plant and soil sciences. Increasing questioning of the need for courses in several areas, including introductory courses, as they are now taught.
- Criticism of excessive overlap in content of courses in the plant and soil sciences; failure to take advantage of knowledge the student has gained in prerequisite courses.
- The prospect of extensive development, in the near future, of post-high school, less-than-baccalaureate programs that will train technicians in the plant and soil sciences.
- Possible need for increased environmental and international orientation in undergraduate courses and curricula in the plant and soil sciences.

*The term "agriculture" as used in this paper, includes also "renewable natural resources."

- The intense competition for education resources, demanding the best possible teaching in the plant and soil sciences as well as in all other subjects.
- Nationwide population shifts, resulting in an increasingly high percentage of the population being poorly informed about plant and soil sciences and other areas of agriculture.
- Increasing need for changes in plant and soil science course offerings better to serve students who are majoring in other areas of agriculture.

It is increasingly difficult for many professors and even many plant and soil science departments, through collective efforts, to be aware of new instructional materials, to select the most appropriate subject matter, and to adopt the most effective teaching methods. Lack of time and funds often limits the availability of visual aids and other teaching resources. Furthermore, local traditions and pressures sometimes result in obsolete and otherwise inappropriate course content and array of courses.

The existence of forces that make change necessary or desirable, coupled with experimentation and development of new undergraduate courses and curricula and teaching methods, indicates that the timing of this conference is appropriate.

POSSIBLE ACTION

The most important result of this conference may be to stimulate and guide individual professors and institutions. On the other hand, interinstitutional activities could result, directly or indirectly. These kinds of activities could make possible the pooling of knowledge by a number of institutions. Ideas could be expressed and discussed unencumbered by local restrictions.

Another result of the conference might be the preparation of new instructional materials. While such materials should be useful to all colleges offering instruction in the plant and soil sciences, they would be especially valuable to: (i) younger teachers and those not involved in, or close to, research; (ii) institutions planning new or revised plant and soil science teaching programs, (iii) institutions with relatively limited resources, and, possibly, (iv) educational institutions in emerging countries.

It is not intended, however, that such materials be rigid and prescriptive; rather, they could serve as catalysts for making desirable changes and should be adapted to meet individual needs.

Following is a list of possible actions offered for conferees to consider. It is not intended to be all-inclusive, nor are all the items mutually exclusive.

1. Preparation of such instructional materials as:
   - Sourcebooks of laboratory exercises, experiments, and lecture material on specific topics. These could be developed by identifying and adapting pertinent features of outstanding research projects for undergraduate instruction purposes. The rationale for this approach lies in the belief that (i) undergraduate teaching often lags behind the forefront of research, and time and pooling of talent may be needed to adapt research results for effective presentation in undergraduate teaching; (ii) such a sourcebook has been prepared in plant pathology and perhaps other areas; (iii) other sourcebooks, drawing more heavily from existing laboratory exercises, have been prepared for crop science and soil science.
   - Single-concept films, television tapes, and other audiovisual materials.
   - Paperback books for supplemental reading.
   - Programs for use in computer-assisted instruction.

2. Compilation of a selected bibliography of materials available for teaching, including texts, laboratory manuals, pamphlets, magazine and journal articles, and films and other visual aids.

3. Compilation of selected available plant and soil science curriculum outlines and course syllabi.

4. Initiation of course and curriculum development projects such as:

- A project to recommend desirable courses for undergraduate majors in the plant and soil sciences. This project could be limited to courses in the plant and soil sciences or could encompass courses in all natural and social sciences and mathematics.
- A project, or several projects, to produce listings of concepts that may be organized into lectures and laboratory exercises or detailed syllabi, either for traditional course patterns (e.g., plant genetics, pathology, physiology) or for new course patterns.

5. Experimentation with new teaching techniques and equipment, possibly combined with development or trial of new instructional materials.

6. Experimentation with new approaches in the laboratory.

7. Summer institutes, summer conferences, and other programs for in-service training. These programs have been set up by the plant pathological, botanical, and other societies.

Numerous national and local projects to upgrade undergraduate teaching in various areas of science, mathematics, and engineering are under way. Any projects stemming from this conference would perforce be part of a nationwide effort.

Activities involving interinstitutional collaboration might be sponsored by individual institutions, by a group of institutions, by scientific and professional societies, or by some other group. Outside financial support, if needed, might be solicited from public and private granting agencies, scientific and professional societies, or elsewhere.

CHALLENGE

We must focus on the future, considering the characteristics and trends of the plant and soil industry as well as the changing demands upon the scientists and other professionals.

The conferees are challenged to be farsighted and innovative. Traditional patterns should be disregarded if more effective approaches can be devised. For example, the traditional array of course offerings can be ignored; typical prerequisites, and the sequence and year-level of plant and soil science subjects might be reconsidered. New adaptations of technological innovations such as computers and television should be considered.

Action following the conference will depend on: (i) ideas expressed and decisions and recommendations made during the conference; (ii) resulting action by individuals, institutions, and professional societies; and (iii) availability of financial support. It is intended that the conference proceedings be published and made available to plant and soil scientists and to those in agriculture and related disciplines generally.

APPENDIX B

Conference Participants and Observers

PARTICIPANTS

ERVIN H. BARNES,* Associate Professor, Plant Pathology, Department of Botany and Plant Pathology, Michigan State University, East Lansing, Michigan

THEODORE C. BIGGER, Professor, Plant and Soil Sciences, Department of Agriculture, Middle Tennessee State University, Murfreesboro, Tennessee

A. W. BURGER, Professor of Agronomy, University of Illinois, Urbana, Illinois

J. A. CAMPBELL, Chairman, Department of Chemistry, Harvey Mudd College, Claremont, California

RICHARD J. CAMPANA, Professor of Botany, Department of Botany and Plant Pathology, University of Maine, Orono, Maine

JOHN CAREW, Chairman, Department of Horticulture, Michigan State University, East Lansing, Michigan

RICHARD B. COREY, Department of Soils, University of Wisconsin, Madison, Wisconsin.

IRA W. DEEP, Associate Professor, Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon; Staff Biologist, Commission on Undergraduate Education in the Biological Sciences, Washington, D.C.†

JAMES V. DREW, Professor of Agronomy, Soils Division, Department of Agronomy, University of Nebraska, Lincoln, Nebraska

RODNEY J. FINK, Associate Professor of Agriculture, Murray State University, Murray, Kentucky

ARTHUR W. GALSTON, Professor of Biology, Yale University, New Haven, Connecticut

JAMES H. M. HENDERSON, Head, Department of Biology, Tuskegee Institute, Tuskegee, Alabama

F. L. HIMES, Associate Professor, Department of Agronomy, The Ohio State University, Columbus, Ohio

HYDE S. JACOBS, Director, Kansas Water Resources Research Institute, Kansas State University, Manhattan, Kansas

C. C. LEWIS, Professor of Agronomy, Virginia State College, Petersburg, Virginia

M. A. MASSENGALE, Head, Department of Agronomy, University of Arizona, Tucson, Arizona

MELVIN S. MORRIS, Professor of Range Management, School of Forestry, University of Montana, Missoula, Montana

RALPH L. OBENDORF, Assistant Professor of Field Crop Science, Department of Agronomy, Cornell University, Ithaca, New York

L. C. PEIRCE, Chairman, Department of Plant Science, University of New Hampshire, Durham, New Hampshire

G. ALLEN SHERMAN, Dean of Agricultural Science and Home Economics, Mt. San Antonio College, Walnut, California

RALPH R. SMALLEY, Chairman, Department of Ornamental Horticulture, State University of New York Agricultural and Technical College, Cobleskill, New York

ROBERT C. SNIDER, Associate Executive Secretary, Department of Audio-Visual Instruction and Assistant Director, Division of Educational Technology, National Education Association, Washington, D.C.

R. B. STEVENS, Executive Secretary, Division of Biology and Agriculture, National Research Council, Washington, D.C.

E. C. STEVENSON, Director of Resident Instruction, School of Agriculture, Oregon State University, Corvallis, Oregon

*Deceased

†Department of Plant Pathology, The Ohio State University since January 1, 1968.

EARL L. STONE, Professor of Forest Soils, Department of Agronomy, Cornell University, Ithaca, New York

BENJAMIN B. STOUT, Associate Professor of Forestry, Department of Horticulture and Forestry, Rutgers University, New Brunswick, New Jersey

W. A. WILLIAMS, Professor of Agronomy, Department of Agronomy, University of California, Davis, California

DAVID G. WILSON, Research Coordinator, Bureau of Land Management, U.S. Department of the Interior, Washington, D.C.

OBSERVERS

JAMES H. ANDERSON, Head, Department of Agricultural Engineering, Mississippi State University, State College, Mississippi

DONALD J. AYO, Head, Department of Agriculture, Francis T. Nicholls State College, Thibodaux, Louisiana

B. O. BLAIR, Professor, Field Crops, Department of Agronomy, Purdue University, Lafayette, Indiana

JOSHUA FELDSTEIN, Chairman, Plant Science Division, Delaware Valley College of Science and Agriculture, Doylestown, Pennsylvania

A. A. HANSON, President, Crop Science Society of America; Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland

D. E. HERR, Assistant Professor of Crop Production, Department of Agronomy, The Ohio State University, Columbus, Ohio

A. FURMAN ISBELL, Professor and Acting Head, Department of Chemistry, Texas Agricultural and Mechanical University, College Station, Texas; Senior Staff Assistant, Advisory Council on College Chemistry, Palo Alto, California

D. P. McGILL, Professor, Crops, Department of Agronomy, University of Nebraska, Lincoln, Nebraska

PAUL R. POFFENBERGER, Assistant Dean for Instruction, College of Agriculture, University, of Maryland, College Park, Maryland

E. C. ROBERTS, Professor, Turf, Department of Horticulture, Iowa State University, Ames, Iowa

D. G. SMELTZER, Lecturer, Department of Agronomy, University of California, Davis, California

L. H. SMITH, Associate Professor, Crop Physiology, Department of Agronomy and Plant Science, University of Minnesota, St. Paul, Minnesota

RICHARD M. SWENSON, Director of Resident Instruction, College of Agriculture, Michigan State University, East Lansing, Michigan

L. N. WISE, Vice President for Agriculture and Forestry, Mississippi State University, State College, Mississippi

COMMISSION ON EDUCATION IN AGRICULTURE AND NATURAL RESOURCES

R. E. LARSON, Chairman; Dean, College of Agriculture, The Pennsylvania State University, University Park, Pennsylvania

GEORGE A. GRIES, Head, Department of Biological Sciences, University of Arizona, Tucson, Arizona*

DARREL S. METCALFE, Director of Resident Instruction, College of Agriculture, University of Arizona, Tucson, Arizona

R. E. GEYER, Executive Secretary, Washington, D.C.

*Dean, Arts and Sciences, Oklahoma State University, since July 1, 1968.

APPENDIX C

WORKING GROUP ASSIGNMENTS

Conference on Undergraduate Teaching in the Plant and Soil Sciences

Monday Afternoon, March 20

Curriculum Content	Course Content	Instructional Materials	Instructional Methods Equipment and Facilities; and the Laboratory	Faculty Development
C - CAMPANA	C - MERWINE	C - WILLIAMS	C - HIMES	C - MASSENGALE
R - SHERMAN	R - SMALLEY	R - McGILL	R - FINK	R - SMELTZER
Bigger	Carew	Burger	Barnes	Ayo
Drew	Lewis	Hanson	Blair	Deep
Galston	Obendorf	Jacobs	Campbell	Poffenberger
Henderson	Smith	Stevens	Corey	Stevenson
Herr	Wilson		Feldstein	Stone
Morris			Isbell	
Peirce			Roberts	
			Stout	

Tuesday Morning, March 21

Introductory Courses	Plant Breeding and Plant Genetics; Plant Pathology	Plant Physiology	Plant Ecology and Management	Soils
C - STEVENSON	C - BARNES	C - HENDERSON	C - MORRIS	C - DREW
R - BLAIR	R - PEIRCE	R - OBENDORF	R - ROBERTS	R - COREY
Ayo	Campana	Feldstein	Burger	Himes
Bigger	Deep	Galston	Herr	Jacobs
Carew	Hanson	Smith	Massengale	Lewis
Fink	McGill		Stone	Wilson
Isbell	Stevens		Williams	
Merwine				
Poffenberger				
Sherman				
Smalley				
Smeltzer				
Stout				

C = Chairman
R = Recorder

APPENDIX D

Conference Program

MONDAY, MARCH 20

MORNING

Registration

Plenary Session
R. E. Larson, Dean, College of Agriculture, The Pennsylvania State University; Chairman CEANAR, Presiding

Introduction
CEANAR goals and purposes of the conference—Dr. Larson

Future Directions for Plant and Soil Science Teaching
H. J. Carew, Head, Department of Horticulture, Michigan State University

Improving Instructional Materials for Undergraduate Teaching
A. W. Burger, Professor, Crop Production and Forages, University of Illinois (Chairman, Teaching Improvement Committee, Crop Science Society of America)

Instructional Technology in Higher Education
Robert C. Snider, Associate Executive Secretary, Department of Audio-Visual Instruction and Assistant Director, Division of Educational Technology, National Education Association

The Role of the Laboratory
J. A. Campbell, Head, Department of Chemistry, Harvey Mudd College; member, Advisory Council on College Chemistry

In-Service Faculty Education
Ira W. Deep, Associate Professor, Plant Pathology, Oregon State University; Staff Biologist, Commission on Undergraduate Education in the Biological Sciences (CUEBS)

AFTERNOON

Working Groups
Curriculum. Course Content. Instructional Materials. Instructional Methods, Equipment, and Facilities; and the Laboratory. Faculty Development.

EVENING

Plenary Session
George A. Gries, Head, Department of Biological Sciences, University of Arizona; member CEANAR, presiding
Discussion Report of Working Groups

TUESDAY, MARCH 21

MORNING

Plenary Session

Plant and Soil Science Teaching in Two-Year Institutions
G. Allen Sherman, Dean, Agricultural Science and Home Economics, Mt. San Antonio College, Walnut, California

Working Groups

Teaching Introductory Courses. Teaching Plant Breeding and Plant Genetics, and Plant Pathology. Teaching Plant Physiology. Teaching Plant Ecology and Management. Teaching Soil Sciences.

AFTERNOON

Plenary Session

Darrel S. Metcalfe, Director of Resident Instruction, University of Arizona; member, CEANAR, presiding

Report from morning working groups. Discussion of working groups. Discussion of mechanisms for implementing proposed action. Adjournment.

APPENDIX E

Commission on Education in Agriculture and Natural Resources

The Commission was formed in 1960 as the Committee on Educational Policy in Agriculture by the Agricultural Board, a unit of the Division of Biology and Agriculture, National Research Council. The Committee became the Commission on Education in Agriculture and Natural Resources on July 1, 1965.

Members of the Commission are*:

R. E. LARSON (Chairman), Dean, College of Agriculture, The Pennsylvania State University, University Park, Pennsylvania

H. B. BARKER, Dean, School of Agriculture and Forestry, Louisiana Polytechnic Institute, Box 1277, Technical Station, Ruston, Louisiana

GEORGE A. GRIES, Dean, Arts and Sciences, Oklahoma State University, Stillwater, Oklahoma

CARROLL V. HESS, Dean, College of Agriculture, Kansas State University, Manhattan, Kansas

A. R. HILST, Professor, Department of Agronomy, Purdue University, Lafayette, Indiana

ROY M. KOTTMAN, Dean, College of Agriculture and Home Economics, The Ohio State University; Director, Ohio Agricultural Research and Development Center; and Director, Ohio Cooperative Extension Service, Columbus, Ohio

DARREL S. METCALFE, Director of Resident Instruction, College of Agriculture, University of Arizona, Tucson, Arizona

LLOYD E. PARTAIN, Assistant to the Administration on Recreation, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.

RICHARD H. WELLMAN, Vice President and General Manager, Process Chemicals Division, Union Carbide Corporation, 270 Park Avenue, New York, New York

R. E. GEYER, Executive Secretary

Information about other Commission publications and programs can be obtained from the Commission on Education in Agriculture and Natural Resources, National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418.

*As of October 1, 1968.